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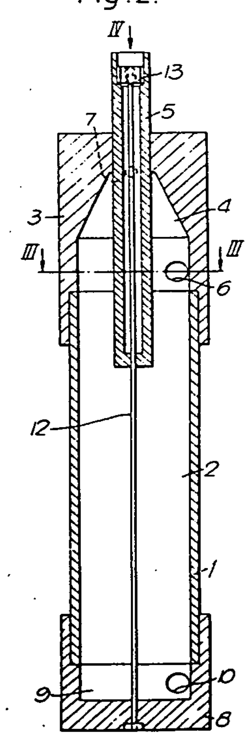
(54) Degassing device

(57) In a degassing device the liquid, e.g. blood, is caused to move in a downward helix in a chamber 1, gas being separated from the liquid by centripetal force and tending to accumulate in the centre of the helix and rise. To assist the accumulation of gas and reduce turbulence a solid surface, e.g. a tube 12, may be provided axially of the helical liquid path. The pressure in the liquid at the bottom of the helical path may be greater than that at the top, increasing the buoyancy of gas bubbles. This pressure rise can be caused by a revessal of the direction of angular flow of the liquid near the outlet 10. The device may take the form of a cylinder with tangential inlet 6 and outlet 10 tubes. In another embodiment, the liquid flows through a duct following a radially decreasing downward helix, the duct has radially inward orifices to allow gas to escape into a central space.

Fig. 2.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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SPECIFICATION

Degassing device for liquids

This invention relates to a degassing device for liquids especially blood, which is used e.g. in high flow rate extracorporeal treatment of blood. It will be described herein with reference to blood degassification. A particularly important example of the use of such a device with blood is in a cardio-pulmonary bypass procedure when major heart surgery is being performed on a patient.

As blood is returned to the patient, it is treated for the removal of particles and especially for the removal of bubbles of gas. These even if they are only of microbubble size (say up to about 40 micron) can cause serious damage to body functions. Conventionally filters have been used for this task, but when they are fine enough to have effect in removing gas bubbles down to microbubble size they increasingly tend to produce so-called formed element damage, wherein the platelets become agglomerated and cell damage may occur.

If a radically new approach to this removal problem could be formulated it would be of great importance in the field, and it is such a radical new approach which we are suggesting here.

In this invention we are proposing the removal of gas bubbles from blood by apparatus and by operations which do not involve passing the blood through any filter medium or mesh. Of course the apparatus and method about to be described may be used in conjunction with a filter, but the filter can be a comparatively coarse-mesh one for the removal only of foreign particles or clots.

The invention relies on causing blood (or other liquid) to be subjected to a pressure gradient within itself as a result of being forced into a flow pattern in which a centrifugal force is generated within the blood. The blood before it is returned to the patient is caused to execute a circular movement at comparatively high velocity, as a result of which gas bubbles tend to flow towards the centre. There they are collected.

One particularly preferred device has a circular-walled chamber into which blood is introduced tangentially, and in which there is a centrally positioned and axially extending solid thin core element, which has the primary functions of stabilising the swirl which is set up in the chamber by the tangential introduction of blood and of offering a surface upon which the bubbles will tend after having travelled towards the centre to aggregate and therefore to rise more readily to a vent. The outlet from the chamber will be below the level of the inlet, so that the movement of the blood is helical for most of its travel through the chamber. But it is an important feature of this device that a flow reversal should occur immediately before the outlet, whereby the blood loses angular velocity and by virtue of this the perceived pressure in the blood is raised to enhance the tendency of the separated bubbles to rise. This reversal is very simply and conveniently effected by disposing the outlet also tangentially to the chamber wall but in the opposite sense to the inlet. The separated bubbles rising along the core enter a venting duct extending downwards into the chamber and which surrounds the core at the upper end of the latter. The top of the chamber should offer a secondary vent for larger bubbles which may separate immediately from the blood on inflow or which may escape the venting duct.

A second embodiment which is indistinguishable in principle imposes circular movement on the blood by passing it along a helical path defined by a helical duct, most conveniently a tube, disposed around a circular wall of a chamber, which should taper downwardly, the duct having on its inwardly facing wall orifices through which bubbles urged inwardly by the pressure differential can escape into an inner plenum and there rise to a vent. The conicity of the chamber would cause a pressure rise toward the bottom end of the chamber to assist the rise of the bubbles. Excessive dead space can be avoided by the presence of a filler body in the chamber. The best orientation of the orifices is found to be from about 40 to 50 degrees say about 45 degrees above the horizontal from the centre line of that part of the duct.

Particular embodiments of the invention will now be described with reference to the accompanying drawings, wherein:-

Figure 1 is a side view of a first embodiment

Figure 2 is a sectional elevation on the line II-II, Figure 1

Figure 3 is a section on the line III-III, Figure 2

Figure 4 is a plan view on a larger scale on the arrow IV, Figure 2

Figure 5 is a diagrammatic side view of a second embodiment

Figure 6 is a detail, in section and

Figure 7 is a plan view.

In the first embodiment a device for degassing blood includes a hollow cylindrical tube 1 forming a chamber 2. The device is to be used with the axis of the tube vertical or approximately so. At the top end of the tube there is cemented or otherwise suitably secured an end fitting 3 having a conical taper which is the head of the chamber, and into which passes, through an aperture formed in the fitting, a tube 5 which acts as a vent duct. To the free end of the tube 5 flexible tubing (not shown) returns vented gas/blood mixture into the extracorporeal circuit in conventional fashion.

The fitting 3 has also a tangentially directed bore 6 which is a blood inlet and which opens into the cylindrical part of the chamber, and a radially directed bore 7 which is a secondary venting duct and which opens into the apex of the taper 4.

At the bottom of tube 1 is a second end fitting 8 having very near the lowest level of its internal void 9 a tangentially directed bore 10 which is a blood outlet. Outlet 10 underlies the inlet 6 (or may have any other angular relationship to it) but always is the same tangent to the circular wall 11 of the chamber 2. The effect of this is that blood swirling in the chamber as a result of having been introduced tangentially into it must lose its angular momentum before, in effect, reversing to flow out of the outlet.

A thin core for the chamber is formed by a fine

tube 12 which is positioned, preferably under pretension, axially centrally in the chamber between an anchorage in the end fitting 8 and a spider 13 borne by a ledge in the tube 12. The primary functions of the tube 12 are to stabilise the helical swirling flow which is to be set up in the chamber (so that the greater rigidity of a tube as compared to a rod is desirable) and to offer a surface for attracting separated bubbles.

In use, blood is passed at high flow rates, typically just over 4 litres a minute, into the inlet. The outlet leads, perhaps through a small and coarse mesh filter for separation of any particles in the blood, to the patient. Return tubing takes vented material from tube 5 and secondary vent 7 to the blood treatment apparatus in conventional fashion.

The rate of flow of blood and/or the pressure induced externally in the tube 5 is such that no true vortex is set up in the chamber, but a rotating swirling helical motion in which there is no central void. This produces a substantial pressure gradient within the blood with a minimum at the centre, towards which bubbles travel (being less dense than blood) and are attracted to the surface of the tube 12. They rise up this and are received into the tube 5. The reversal of blood flow at the outlet 10 causes an effective pressure rise in the blood at the bottom of the chamber thus increasing the buoyancy of the bubbles of gas. Any bubbles which escape the tube 5 or any macrobubbles in the incoming blood rise to the apex of the taper 4 where they are taken out through bore 7.

As can be seen this device has a very simple conformation and can readily be made, by unskilled labour, from a small number of parts moulded or extruded from plastics material.

In the second embodiment a frusto-conical chamber 20 has a helical path for blood formed around its inner wall. As shown, a tube of PVC or the like is laid in a coil around that wall and has an inlet 21 at its top and an outlet 22 at its bottom. In Figure 7 two possibilities for the disposition of the outlet are shown, position 22 involving a reversal of flow as before, position 22' involving no such reversal. On the inwardly-facing surface of the tube there is provided a multiplicity of small orifices 23. These are positioned at an angle 24 above the horizontal of that part of the tube which is of the order of 45 degrees.

A plenum 25 of the chamber is formed between the wall and a correspondingly frusto-conical filler member 26. This at the same time offers an aggregation surface for the bubbles of gas which pass, under the pressure differential generated in the tube, through the orifices 23 and a means to cut down the dead drainage space within the chamber 20.

The chamber has a head 27 which offers an inverted funnel at the top of which is a venting duct 28.

In this embodiment the dwell time of any given aliquot of blood is longer than in the first embodiment and a sufficient secondary flow and pressure gradient causing the bubbles to rise may be achieved merely by the conicity of the chamber. Otherwise the functioning of this embodiment is as described with reference to the first.

CLAIMS

1. A degassing device for liquids including a chamber intended to be used with its axis vertical or substantially so, in which the liquid is caused to flow in a helical path from an inlet to the chanber downwardly to an outlet thereof whereby to exert a centripetal force on any bubbles in the liquid and a gas outlet at the top of the chamber.
2. A degassing device according to claim 1 wherein the liquid inlet is tangential to the wall of the chamber.
3. A degassing device according to claim 2 wherein the liquid outlet is tangential to the wall of the chamber.
4. A degassing device according to any one of the preceding claims which is arranged such that the pressure in the liquid at or near the liquid outlet is higher than the pressure in the liquid at or near the liquid inlet.
5. A degassing device according to claim 4 wherein the higher pressure is caused by reversing the angular direction of the liquid path near the outlet.
6. A degassing device according to claim 4 wherein the path is of progressively smaller radius.
7. A degassing device according to any one of the preceding claims in which there is along the axis of the chamber a fixed solid surface on which bubbles of gas separated from the liquid may accumulate and rise.
8. A degassing device according to claim 7 wherein the surface is provided by a narrow tube.
9. A degassing device according to any one of the preceding claims in which the helical path is defined by a helically disposed duct lying radially inside the chamber wall and through which the liquid flows, the duct having orifices along its surface through which bubbles of gas may escape from the duct towards the axis of the chamber.
10. A degassing device according to claim 9 in which the orifices are positioned above the centre line of the duct, a line from any orifice to the centre line of the duct being angled at about 45° to the axis.
11. A degassing device substantially as herein described with reference to and as illustrated in Figures 1 to 4 of the accompanying drawings.
12. A degassing device substantially as herein described with reference and as illustrated in Figures 5 to 7 of the accompanying drawings.

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Fig. 3.

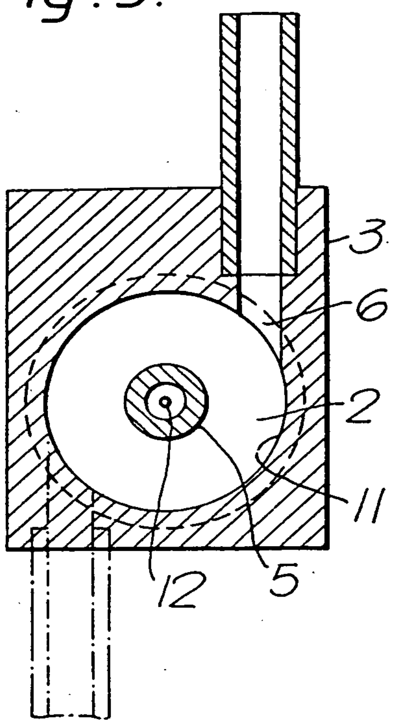

Fig. 4.

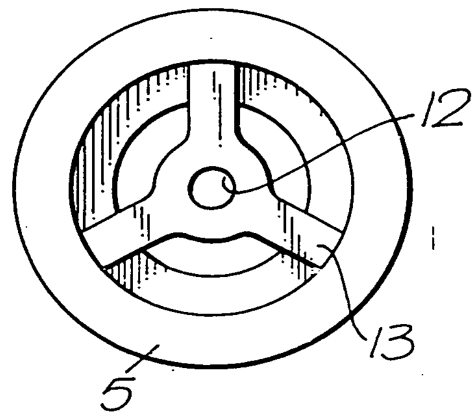

Fig. 7.

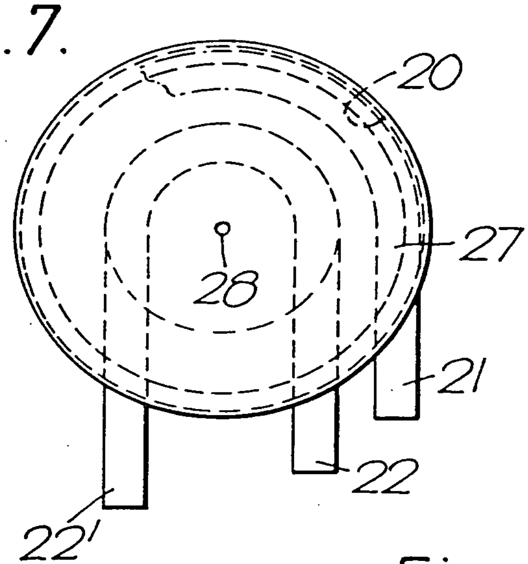

Fig. 5

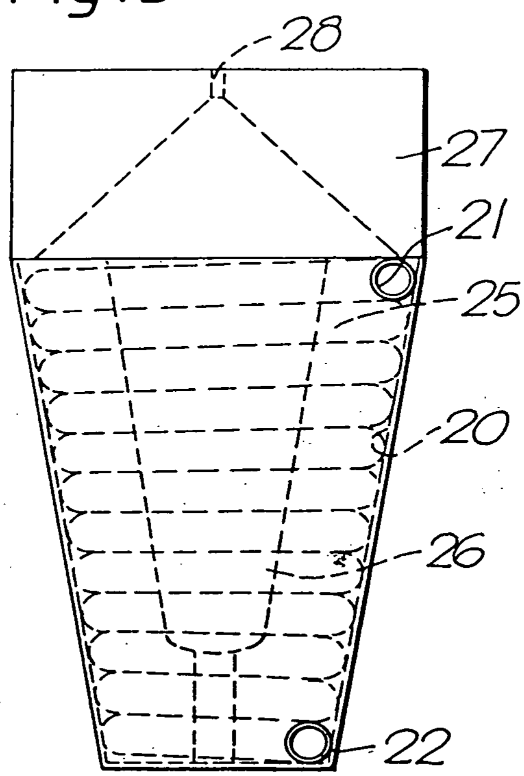

Fig. 6.

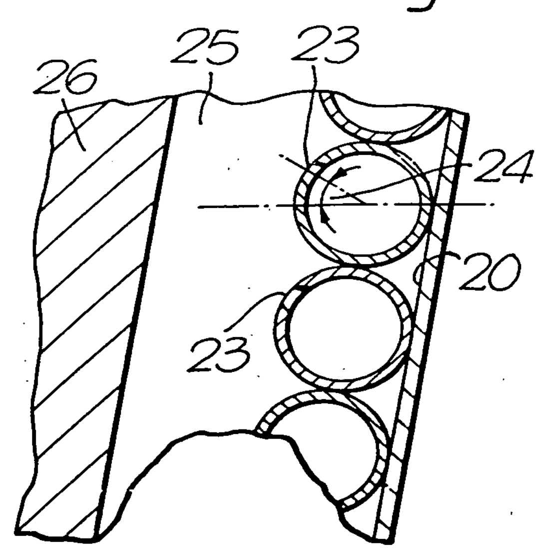

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Fig. 1

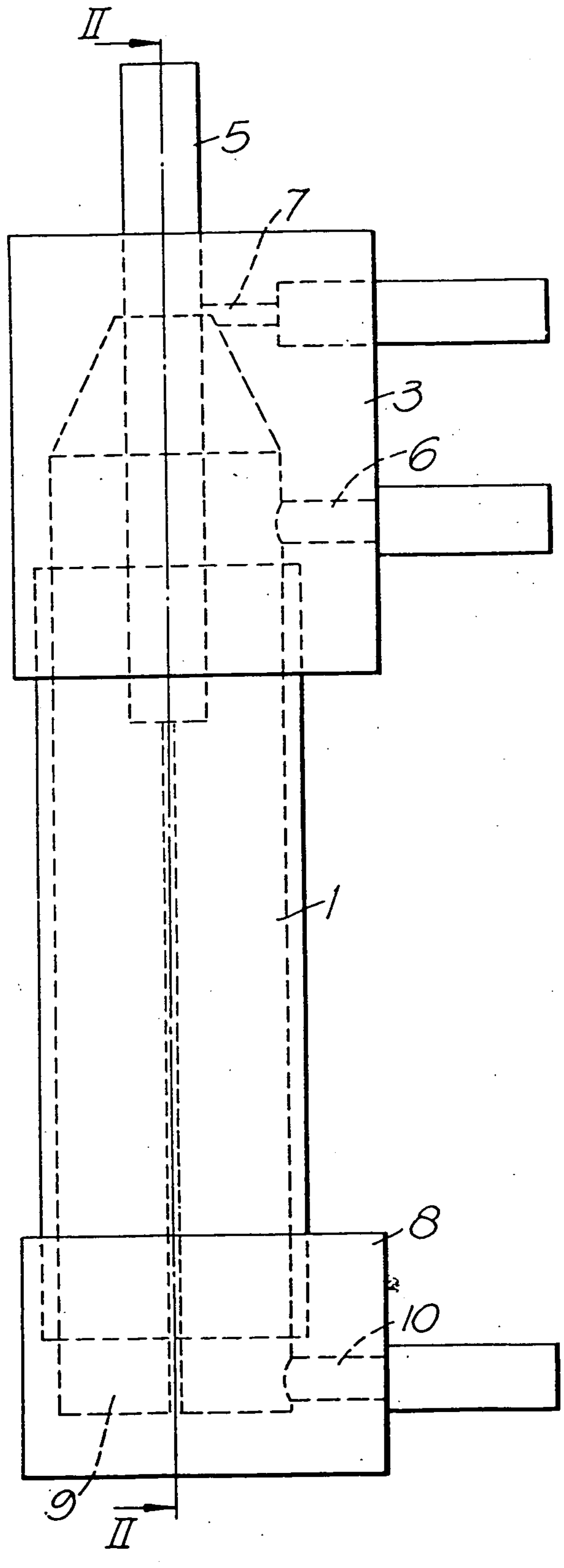

Fig. 2.